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DIFFERENTIATION AND DEVELOPMENT OF FRUIT BUDS IN "SUPERIOR" GRAPE VARITEY

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ABSTRACT

Differentiation and sequential anatomical features of the fruit buds in "Superior" grape variety were investigated. The entire process of fruit bud differentiation was classified into seven stages and completed in two growth seasons. Differentiation of the inflorescence primordium reaches its completion in the first season, while differentiation of the floral primordium occurs during the second growth season. The results indicate that most of the proximally inserted fruit buds at basal part of the shoot are more advanced in differentiation than those inserted at distal part of the shoot.

This study indicates that the dissecting technique of the fruitful buds during winter can be a reliable guide of yield in the subsequent growth reason.

INTRODUCTION

Determination of the exact time of initiation and development of both inflorescence and floral primordia will help to appreciate these stages especially in regard to the nutritional need. In addition, it will also help to forecast the fruiting potential for the next growth season through examination of bud fertility in advance. Also, it may be determine cane length or fruit spur during winter pruning. The fertile bud formation in grapevines (*Vitis vinifera*. L.) begins with the initiation of inflorescence primordium, followed by its determination and terminated with the initiation and development of flower organs. The entire process is recorded by many researchers as fertile bud differentiation (Lavee *et al.*, (1967), Alleweldt and Ilter (1969), Madhava Roa and Mukherjee (1970) and Oraman and Agaoglu (1970). Flower primordium is shown to occur in the ensuing growth season at which inflorescence primordium was formed Madhava Roa and Mukherjee (1970) and Scholefield and Ward, (1975). In contrary, Alleweldt and Balkema (1965) and Agaoglu (1971) observed the initiation of floral primordia in some grape cultivars occurring in late autumn of the same season of inflorescence formation.

In the grapevine inflorescences are formed in latent buds in May-July in the year preceding their appearance on shoots. The period of bud differentiation and bud fertility (average number of inflorescences on the main axis of latent buds) were studied in 6 cvs (10-year-old) grafted on Rupestris du Lot and trained on the Royat system. Differentiation began on 11-13 May in Corinthe Noir, Mavroudi and Cardinal, on 19-21 May in Opsimos Edessis and Razaki and on 24-26 May in Sultanine Blanc. Bud fertility was in the decreasing order Mavroudi 2.13, Corinthe Noir 1.97, Opsimos Edessis 1.89, Cardinal 1.74, Razaki 1.10 and Sultanine Blanc 0.89. No correlation was noted between the period of inflorescence differentiation and that of grape maturity but differentiation and flowering periods appeared to be correlated. In all cvs, apart from Sultanine Blanc, bud differentiation was generally completed before the end of flowering (Vlachos, 1979).

In "Romi Red" grapevines, Initiation of the first inflorescence primordium is seen on May 20, and the time taken from bud burst is 52 days.

Since the protrusion in the stage 1 could be differentiated to inflorescence or tendril, the stage can be identified as prefloral meristem. The visible feature of stage II was first observed on June 5, meaning 68 days after the time of bud burst. The stage III of fruit bud differentiation is observed on June 20, i.e. 83 days after bud burst. (Hifny, 1982).

All the cultivars studied (table cultivars Razaki, Cardinal, Hambourg musque and Opsimos Edessis and raisin cultivars Corinthe noir and Sultanine blanche) completed the differentiation of primary latent buds before the end of flowering. There was no correlation between the time of differentiation of primary latent buds and that of grape maturation. The fertility of primary latent buds depended on the cv., bud position on the shoot, and climatic factors during the period of differentiation. (Vlachos, 1983).

A study investigating the initiation, differentiation, and potential and actual fertility of fruit buds of Chardonnay grapevines in 3 vineyards in Sicily, Italy, did not indicate any statistical differences between the vineyards. Actual fertility ranged from 0.5 to 1.55 and 1.25 near the crown, first node and second node, respectively. (Sparacio *et al.*, 1998).

'Kyoho' grapevines was used as materials to determine the period of flower bud differentiation. Inflorescence differentiation in grapevines can be divided into 3 stages, i.e. nondifferentiation, inflorescence perimordium differentiation and second branching of perimordium. Inflorescence differentiation takes place in the 1st year, while flower organ differentiation in the next year. Starch grains were more likely to accumulate and distribute in the portions which were derived from premeristem, while proteins occurred in the primordial where cells multiplied rapidly. (Yuan *et al.*, 2003).

The objective of this study is to determine the exact time of initiation and development of inflorescence and floral primordia in "Superior" variety grown in Egypt. Besides, a criteria for an early forecasting of fruiting potential is proposed.

MATERIALS AND METHODS

The present work was carried out during the two successive seasons 2002 and 2003, in a vineyard located at El-Khatatba, Monofia governorate. The study was done on the early ripened seedless grapevine variety "Superior". The vines were grown in newly reclaimed sandy soil, 3.5 x 3 m apart, trained using cane training system and trellised through Spanish Barron system. The vines were pruned to 8 canes / vines, each had 15 buds and were irrigated through drip irrigation system. 25 vines similar in growth potential, were selected giving the same weight of prunings wood, to provide the materials (Buds) needed in the present study. The following experiments were conducted.

1. Determination of fruit bud initiation and floral differentiation:-

Sample of five auxiliary buds positioned at the 6^{th}, 7^{th}, 8^{th} and 9^{th} distally node of the shoot were periodically collected beginning on April, 4, 2002 up to December, 15, 2002 at biweekly intervals. Similarly, five inflorescences were collected in the ensuing growth season of 2003, just on the day of their emergence and followed every three days up to time of

flowering in 2003. The collected axillary buds and undeveloped inflorescences were fixed directly after abscission in FAA (Formalin Acetic Acid). After dehydration with alcohol, sample were embedded in paraffin wax. Longitudinal sections 10 μ thick were prepared and stained with Safranin and Fast green (Johansen, 1940). The permanent slides were microscopally inspected by microscope to determine stage of the floral intiation in buds and the floral differentiation (Table 1 & 2 and Fig. 1).

RESULTS AND DISCUSSION

1. Determination of fruit bud initiation and floral differentiation:-

Results of the anatomical study on the axillary buds are shown in Figure 1 Axillary buds collected on April 4, 2002 show no sign of inflorescence primordium (Fig. I.a). This vegetative stage is classified as stage "0" according to Hifny (1982). The growing apex appear pointed dome shape, surrounded with rudiments of leaf primordia and several scales.

Initiation of the first inflorescence primordium is seen on April 19, which was 45 days after bud burst (Fig. I "b" and Table 1). The inflorescence primordium appears like a leteral outgrowth or protrusion that develop from the growing apex. According to Baldwin (1964), Hifny (1982), Sparacio *et al.*, (1998) and María *et al.*, (2002), weather conditions prevailing at the time of formation of inflorescence primordium may affect on its developmental rate. Alleweldt (1964) as well as Alleweldt and Ilter (1969) showed that the protrusion referring to the inflorescence primordium could not be distinguished from tendril primordium in this stage. The primordia for both of these organs are formed at similar position on the terminal meristem of the axillary bud and potentially interchangeable. Little is known about what factors might affect their direction of differentiation.

Since the protrusion in the stage I could be differentiated to inflorescence or tendril, the stage can be identified as prefloral meristem.

The visible feature of stage II was first observed on May 4, meaning 60 days after the time of bud burst. As can be seen in Fig. 1 "c", inflorescence primordium is inserted in the axil of bract and obviously more elongated along the main longitudinal axis. Alleweldt and Balkema (1965), Hifny (1982), Sparacio *et al.*, (1998) and María *et al.*, (2002) showed that inflorescence primordium could be distinguished from that of tendril from a comparison of their rate of elongation.

The stage III of fruit bud differentiation is observed on May 19, meaning 75 days after bud burst (Fig. I "d" and Table 1). The inflorescence primordium is divided into more than one branch of the first order, each subtended by a bract. The branch primordium is subtended by a bract as can be seen in Fig. 1 "e".

Fruit buds collected later indicate that no differentiation is obvious further than branch primordia of the third order. A complete inflorescence primordium formed in fruit buds which were collected on December 15, 2002.

Table 1 shows that initiation of the floral parts occurred 15 days after the bud burst, almost simultaneously with the appearance of inflorescence. The calyx ring was the first observable primordia as can be seen in Fig. 1 g.

Primordia of the other floral parts appeared in the regular order corolla, stamens and carpels. Initiation of petal primordia commenced 9 days after the appearance of inflorescence in season 2003. Staminal primordium become visible 12 days after the appearance of inflorescence (Table 1), subsequently the last structures to develop are the gynoecium primordia, which occupy the central most location of different floral whorls. Gynoecium primordium occurs at 16 days after the appearance of the inflorescence. The begin of embryo death occurred 45 days the bud burst (Fig. 1, "k" and "l").

Following bud burst in growth season 2003, apices of the inflorescence branches show rapid growth and development. The floral parts start to form within almost two weeks of bud burst and all essential organs of the flower are differentiated within the subsequent 16 days.

a) Stage 0 b) Stage I c) Stage II

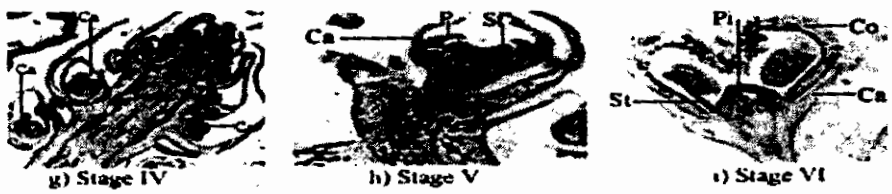
Fig. (1) Stages of fruit bud formation in "Superior" variety

S: scales
G: growing apex
L: leaf primordium
IP: inflorescence primordium

d) Stage III e) Advanced stage III f) Advanced stage III

Fig. (1): Stages of fruit bud formation in "Superior" variety

AB: axillary bud
L: leaf primordium
G: growing apex
B: bract
IP: inflorescence primordium
TP: tendril primordium
1.OB: first order branch
2.OB: second order brabch
3.OB: third order branch



g) Stage IV h) Stage V i) Stage VI

Fig. (1) :Stages of fruit bud formation in "Superior" variety

Ca Calyx
P Petals
St. Stamen
Pi Pistil
Co Corolla

j) Stage VI k) Stage VII l) Stage VIII

Fig. (1) :Stages of fruit bud formation in "Superior" variety

Ps Pistil
St stigma
C corpus
Co corolla
St. stigma
Ov ovule
Ae. aborted embryo

Table (1): Stage of the floral intiation in buds and the floral differentiation in "Superior" variety during season 2002-2003

Stages of fruit bud development	Date	Days after bud burst	Characteristics of the stage
O	April 4, 2002	30	Vegetative bud
I	April 19, 2002	45	Initation of inflorescence primordial
II	May 4, 2002	60	Inflorescence primordium with extended axis
III	May 19, 2002	75	Appearance of 1st order branch primordium
Adv. III	June 3, 2002	90	Development of 2nd and 3rd order branch primordium
Adv. III	February 15, 2003	----	----
IV	March 15, 2003	15	Appearance of floral primordium the calyx
Adv. IV	March 19, 2003	19	Complete differentiation of calyx
V	March 22, 2003	22	Initation of petals primordium
VI	March 25, 2003	25	Initation of stamens primordium
VII	March 28, 2003	28	Initation of carpels primordium
Adv. VII	April 1, 2003	31	Carpels ara fully differentiated
VIII	April 15, 2003	45	The beign of embryo death

Table (2): Time of formation of fruit buds and their percentage at different position in "Superior" variety season 2002

* Bud position	Weeks after bud burst	Vegetative buds (%)	Fruit buds (%)	Stage (1) (%)
6th	4	100	-	-
6th	6	32	68	71
6th	8	22	78	26
6th	10	21	79	-
6th	12	31	69	-
6th	14	29	71	-
7th	4	100	-	-
7th	6	22	78	73
7th	8	34	66	24
7th	10	30	70	3
7th	12	32	68	-
7th	14	22	78	-
8th	4	100	-	-
8th	6	35	56	74
8th	8	30	70	28
8th	10	25	75	9
8th	12	34	66	-
8th	14	26	74	-
9th	4	100	-	-
9th	6	34	66	77
9th	8	36	64	35
9th	10	32	68	-
9th	12	40	60	-
9th	14	38	62	-

* 50 buds were inspected:-
(1) Pre-floral stage (indifferentiated primordium)
(2) Primordium with elongated axis in axis of extended bracts
(3) Primordium with first order branches

2. Prediction of bud fertility in comparison to actual bud fertility:-

This work was performed in the two successive seasons 2002 and 2003. Prediction of bud fertility was carried out according to the method described by Ambika and pondey (1969). 100 canes, each contained 15 buds were taken at pruning time in winter. The 15 buds on the cane were individually examined for fertility using the Stereo microscope. 100 of each bud were examined into fertile or vegetative bud. The percentage of fertile buds for each bud position (from 1 to 15) was recorded and tabulated. On the other hand, the actual fertility of the fifteen buds on the cane was determined through the observing shoots grown from those buds in the ensuing spring. 100 fruitful shoots were determined by random (four shoots / plant) and subjected for recording their position on the cane and number of clusters per each shoot. (Table 3 & 4 and Fig. 2). These results are in agreement with the findings of many workers such as Alleweldt and Balkema (1965), Alleweldt and Iltер (1969), Agaoglu (1971) Hifny (1982), El-Mogy (1982), Sparacio *et al.*, (1998) and Maria *et al.*, (2002) have reported that floral parts are

detected on the inflorescence primordium of some grape cultivars in late autumn of the season of initiation. However, our results are in disagreement with who could not detect the inflorescence primordium of some grape cultivars in late autumn of the season of initiation (Madhava Roa and Mukherjee 1970 and Scholefield and Ward 1975).

As indicated in Table 2, percentages of fruit buds at each node position continuously increased to attain the maximum after 6 weeks from set of the first inflorescence primordium, i.e. 14 weeks after bud burst. Percentages of fruit buds at 7th and 8th node position were nearly similar in the comparable dates and higher than those at 6th and 9th node position.

Node position at which the fruit bud is formed greatly affect the rate of development of inflorescence differentiation. Table 2 shows that fruitful buds at 6th node position exhibit lower percentage of buds reaching stage 1 and higher percentage of buds reaching stage 11 during the first week of differentiation compared with those at 9th node position. The data indicate that the proximally inserted fruit buds at base of the shoot are more advanced in differentiation than distally inserted one towards the shoot tip. This result confirmed the finding of Alleweldt and Iiter (1969) , Hifny (1982), Sparacio *et al.*, (1998) and Maria *et al.*, (2002) who found that the flowering impulse began in the proximal buds and spread towards the distal part of the shoot.

Table (3): The actual fertility of buds of "Superior" variety at different node position season 2002-2003

Insertion of shoot on cane	Fruit buds predicated in winter %	Actual fruit shoots recorded in spring %	Difference between predicted and actual fruit buds %	Fertility of the shoot	
				Shoot with one cluster %	Shoot with two clusters %
1	5	0	5	0	0
2	22	15	7	96	4
3	36	24	12	94	6
4	44	27	17	97	3
5	56	47	9	85	15
6	73	59	14	79	21
7	72	55	17	81	19
8	70	54	16	83	17
9	64	50	14	86	14
10	44	36	8	92	8
11	35	30	5	94	6
12	32	25	7	94	6
13	30	25	5	96	4
14	26	19	7	100	0
15	26	20	6	100	0
$\bar{X}$	42.3	32.4	9.9	85.1	8.2

100 buds were examined

Table (4): The actual fertility of buds of "Superior" variety different node position season 2003-2004

100 buds were examined

Insertion of shoot on cane	Fruit buds predicated in winter %	Actual fruit shoots recorded in spring %	Difference between predicted and actual fruit buds %	Fertility of the shoot	
				Shoot with one cluster %	Shoot with two clusters %
1	7	0	7	0	0
2	17	14	3	92	8
3	32	28	4	90	10
4	40	33	7	93	7
5	59	48	11	88	12
6	76	60	16	82	18
7	78	63	15	83	17
8	73	61	12	83	17
9	60	48	12	86	14
10	46	35	11	89	11
11	33	23	10	91	9
12	31	23	8	94	6
13	26	20	6	93	7
14	24	16	8	98	2
15	23	16	7	98	2
$\bar{X}$	41.7	32.5	9.1	84.0	9.3

Fruit buds that reached stage III of differentiation are observed two weeks after the first appearance of inflorescence primordium. Percentages of fruit buds that reached the stage III were higher in proximally inserted buds than those distally one. Advanced stage III of differentiation is observed in fruit buds at 6th and 7th node position two weeks earlier than at 8th and 9th node position. This finding lends support to the view that most of fruit buds at the proximal part of the shoot are more advanced in differentiation than those inserted at distal part of the shoot.

2. Prediction of bud fertility in comparison to actual bud fertility:-

Results reported in Tables 3 and 4, as well as the Fig.2 indicated that the percentage of predicated bud fertility lengthwise the cane increased gradually to attain the maximum values in the middle part of the cane (from the 6th to the 9th bud), then, a remarkable gradual decrease was observed at the distal buds of the cane (from the 10th to the 15th bud) in the both seasons.

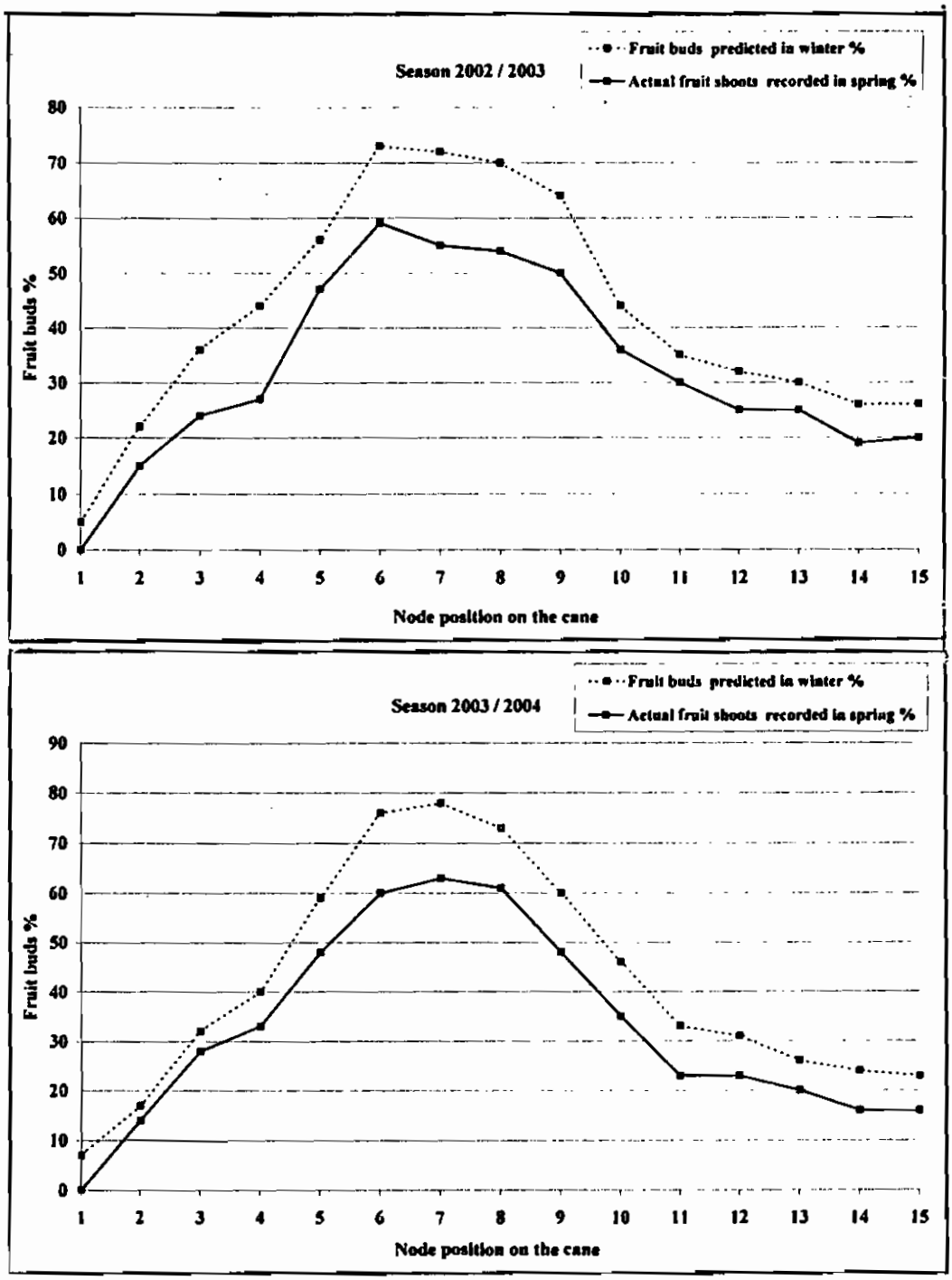


Fig. (2): The predicated bud fertility (Fruit buds %) compared with the actual fruitfulness (fruitfulness %) at different node position in "Superior" variety, season 2002/2003 and 2003/2004.

Data in Tables 3 and 4, as well as the Fig.2 indicate trend of the percentage of fruitful dormant buds detected in December 2002 and 2003 was similar to that of the actual fruitfulness of shoots appeared in the subsequent seasons. The similarity in trend of both predicted and actual fruitfulness suggests that the advance forecasting through the examination of bud fertility during winter may be a reliable guide for winter-pruning and fruiting of "Superior" variety in the ensuing season. However, the actual fruitfulness was less to a great extent than the predicted one arrange between (5-17%). Similar results had been shown by Briza and Milosavlievic (1954), Antcliff and Webster (1955) and Madhava Roa and Mukherjee (1970) , Hifny (1982), Sparacio *et al.*, 1998 and Maria *et al.*, (2002).

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تكشف وتطور البراعم الثمرية فى العنب صنف السوبيريور

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تم تحديد ثمانية مراحل لتطور البراعم الثمرية فى عنب السوبيريور حيث تستغرق فـــى تطورها موسمين متتالين يتم فى الموسم الأول تخليق المبادئ النورية فى حين تبدأ المبادئ الزهرية فى التخليق فى فصل النمو الثانى، وكان بداية تخليق المبادئ النورية يحتاج إلى ٤٥ يوم بعد إنبثاق البراعم فى الربيع فى حين حدث تخليق المبادئ الزهرية فى فصل النمو الثانى ١٥ يوم بعد إنبثاق البراعم وهو نفس الوقت الذى ظهرت فى النورة على الفرخ. وكان ترتيب نفس الأعضاء الزهرية: كأس- تويج- طلع- متاع حيث إكتمل تخليقها فى مدى ١٦ يوم. وبداية موت الجنين بعد ٤٥ يـــوم من تفتح البراعم. وقد إحتوت البراعم الأبكر تكوينا على الفرخ على مبادئ نورية متقدمة التطـــور عن البراعم الثمرية على قمة الفرخ. ومن هذه النتائج يمكن إجراء التقليم الشتوى بطريقة دقيقة كما يمكن التنبؤ مبكرا بمحصول الثمار للموسم التالى وذلك بفحص عينة من البراعم الساكنة أثناء فترة الشتاء بطريقة التشريح تحت مجهر البينوكلار لتحديد درجة خصوبتها، وقد أثبتت دقتها كطريقـــة صحيحة للتنبؤ.